Green Plan Research Workshop

1996

Summaries

Lamplighter Best Western Inn
LONDON, Ontario

March 26 - 27, 1996

FORWARD

This report is one of a series of **COESA** (Canada-Ontario Environmental Sustainability Accord) reports from the Research Sub-Program of the Canada-Ontario Green Plan. The **GREEN PLAN** agreement, signed Sept. 21, 1992, is an equally-shared Canada-Ontario program totalling $64.2 M, to be delivered over a five-year period starting April 1, 1992 and ending March 31, 1997. It is designed to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. The Federal component will be delivered by Agriculture and Agri-Food Canada and the Ontario component will be delivered by the Ontario Ministry of Agriculture and Food and Rural Assistance.

From the 30 recommendations crafted at the Kempenfelt Stakeholders conference (Barrie, October 1991), the Agreement Management Committee (AMC) identified nine program areas for Green Plan activities of which the three comprising research activities are (with Team Leaders):

1. **Manure/Nutrient Management and Utilization of Biodegradable Organic Wastes** through land application, with emphasis on water quality implications
   A. Animal Manure Management (nutrients and bacteria)
   B. Biodegradable organic urban waste application on agricultural lands (closed loop recycling)
   (Dr. Bruce T. Bowman, Pest Management Research Centre, London, ON)

2. **On-Farm Research**: Tillage and crop management in a sustainable agriculture system.
   (Dr. Al Hamill, Harrow Research Centre, Harrow, ON)

3. **Development of an integrated monitoring capability** to track and diagnose aspects of resource quality and sustainability.
   (Dr. Bruce MacDonald, Centre for Land and Biological Resource Research, Guelph, ON)

The original level of funding for the research component was $9,700,000 through Mar. 31, 1997. Projects will be carried out by Agriculture and Agri-Food Canada, universities, colleges or private sector agencies including farm groups.

This Research Sub-Program is being managed by the Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ON. N5V 4T3.

Dr. Bruce T. Bowman
Scientific Authority

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A Context for the Green Plan Research Program

Dr. Bruce MacDonald, Land Resource Div., Agriculture and Agri-Food Canada, Guelph, ON.

The quality of water in the Great Lakes System has been a longstanding concern of both the government of Canada and the government of the United States of America. The rights and obligations of both countries were officially outlined in the spirit of friendship and cooperation in the Boundary Waters Treaty signed on January 11, 1909. In more recent times the obligation not to pollute boundary waters while recognizing the rights of each country in the use of its Great Lakes waters has been reaffirmed in a series of Great Lakes Water Quality Agreements.
The state of the Great Lakes is monitored and reported regularly by the International Joint Commission.

In the Great Lakes Water Quality Agreement (GLWQA) of 1972, emphasis was placed on nutrients from point sources (municipal sewage treatment facilities) as a major concern to water quality in the Great Lakes Basin Ecosystem. In addition, the PLUARG (Pollution from Land Use Activities Research Group) studied rural pollution and confirmed agriculture as a non-point source of pollution.

The GLWQA was reviewed and updated in 1978. In this agreement, target levels were established for phosphorus loadings to the Great Lakes. A phosphorus management plan was developed for the lakes which included pollution from rural non-point sources. SWEEP (the Soil and Water Environmental Enhancement Program) was established to carry out research and transfer of technology related to agriculture. At the time of this agreement a Canada-Ontario Agreement (COA) was signed respecting the Great Lakes Basin Ecosystem. The purpose of the COA was to coordinate the activities of federal departments and provincial ministries in support of the Great Lakes Water Quality Agreement.

The 1987 protocol (an updated version of the GLWQA) emphasis was placed on limiting the release and impact of toxic chemicals in the Great Lakes Basin ecosystem. A non-point source pollution annex was added to the agreement providing detailed targets for various pollutants. The focus of activities was broadened to include an ecosystem approach.

The result of the 1987 protocol was several Great Lakes Action plan (GLAP) initiatives; specifically, the GLAP research program was a five year $ 5 million multi-disciplinary research project carried out from 1989 to 1994. It dealt with agricultural non-point sources of pollution related to pesticides, manure and nitrogen. In addition, there were federal and provincial programs designed to promote permanent cover or maintain high residue ground cover as ways to minimize erosion by water.

The Green Plan agreement was developed as an equally-shared Canada-Ontario program to encourage and assist farmers with the implementation of appropriate farm management practices within the framework of environmentally sustainable agriculture. Approximately 30% of the federal component of this program has been directed towards research (to be reported on at this workshop) to address objectives which were identified at a Stakeholder conference (Kempenfelt Centre, Barrie, October 1991) and subsequently refined by research project committees.

Other Green Plan initiatives deal with technology transfer and demonstration of good innovative practices. These include the Rural Conservation Club Program which is coordinated by the Marketing and Industry Services Branch and has supported more than forty projects developed and carried out by groups of farmers. The woodlands, wildlife and wetlands program has a series of projects designed to promote healthy ecosystems with a mix of agriculture, forest areas and wetlands. The joint federal-provincial program to develop booklets which describe Best Management Practices provide a standard reference for farmers and the general public about the position and interactions of agriculture in the rural ecosystem. The farmer led Environmental Farm Plans are providing several thousand Ontario farmers with an assessment of their individual farming operations.

The most recent Canada-Ontario Agreement (COA) was signed in July 1994. It provides details of cooperative activities to restore, protect and conserve the Great Lakes basin ecosystem. This agreement and other Canadian and international initiatives (listed later) provide an indication of how agricultural and environmental concerns are continuing to evolve. It is these programs as well as others yet to come which will shape our thinking and, in reality, they will provide the context within which the results of our current Green Plan Research projects will be assessed and interpreted. It is important for all of us to take note of these developments and consider not only how well our research projects meet their original objectives but also how they will contribute to new and developing interests and concerns. The following few paragraphs provide a brief outline of recent program and policy developments.

The 1994 COA continues and expands the emphasis on ecosystems which was clearly enunciated in the 1987 Protocol. Four areas of focus (streams) are identified; namely,

- restore degraded ecosystems (RAPs)
- prevent and control pollutant impacts
- conserve human/ecosystem health
- integrated ecosystem management.

These trends represent a more comprehensive and holistic view of agriculture in the environment as it interacts with other ecosystem components (aquatic, wetland, and forest) and the overall societal requirements for quality of life.

Several associated government programs deserve mention because they will provide part of the framework for interpreting Green Plan Research. These include National Environment Strategy for Agriculture and Agri-Food, State of Environment Reporting and Indicators. The activities related to indicators encompass the Environmental Indicator Bulletin Series produced by Environment Canada, the Agri-Environmental Indicators being developed by Agriculture and Agri-Food Canada and the OECD (Organization for Environmental Cooperation and Development) indicators which are currently under development.

The first draft of the National Environment Strategy for Agriculture and Agri-Food was circulated in 1990 as the report on Environmental Sustainability. In 1995 this report is being revised. Four main issue areas are identified;

resource-based issues
regulatory issues
trade issues
awareness and education issues.

The results of Green Plan research projects will contribute most directly to the section dealing with resource-based issues.

Environment Canada produced the first State of Environment (SOE) Report in 1986 to correspond with the census. The third SOE report is scheduled for release after the 1996 census. It will provide a general assessment of sustainable development within an ecosystem framework. In simple terms this third SOE report will attempt to answer four key questions related to agriculture and sustainable development;

what is happening? (Conditions and trends)
why is it happening (links between human activities and ecological changes such as environment-economy interactions)
why is it important (what are the implications for ecosystems, human health, economic and social well-being i.e. are the trends sustainable?)
what are we doing about it? (Responses at all levels of society).

Clearly, most Green Plan research projects deal very directly with one or other of these questions.

Indicators are developed to provide information which is clear and easily understood on the current trends and state of the natural environment in agriculture, to assist policy makers in the analysis of the environmental

impacts of policy decisions and market processes, and to monitor the effectiveness of policies promoting sustainable agriculture. In general, we must first carry out sound scientific study and documentation of a situation and then provide a more simplified view for broader distribution. In Canada there are three specific indicator activities underway. The Environment Canada Indicator Bulletin Series is designed to monitor and report trends for the public at large. The Agri-Environmental Indicators under development by Agriculture and Agri-Food Canada will monitor trends and provide a tool to evaluate the effects of policies. The OECD Agri-Environmental indicators will be used to facilitate inter-national agri-environmental comparisons for purposes of trade. A cooperative project is underway with INRA (Institut National de la Recherche Agronomique), France to model the movement of potential contaminants in small watersheds. The resulting workshops and parallel studies will contribute to the indicator of risk of water contamination.

The Green Plan Research Projects were developed through a consultative process to address the needs of the agricultural community in addition over and above the ongoing A-base research activities. The objectives identified at the outset remain of primary importance as the research is carried out. However, we as coordinators of the research would be remiss if we did not pay close attention to developing programs, concerns and interest and all of us as an agricultural research community need to continue to reevaluate how our research activities can be integrated with other research initiatives to contribute to societies needs. We will continue to share our understanding of trends with you and count on your input and discussion assist all of us in achieving the most useful interpretations and applications of our efforts.

Projects Completed by March 31, 1996

1.1 Literature Search on Manure/Nutrient Management
Contractor: Dr. Michael Goss, Dept. of Land Resource Sci., U. of Guelph, Guelph, ON, N1G 2W1
Status: ***COMPLETED , AVAILABLE SEPT. 1994*** **COESA Report No.: RES/MAN-001/94**

1.9 Literature Review on Wildlife Habitats in Agricultural Landscapes
Contractor: Mr. Lyle Friesen, Canadian Wildlife Service, Environment Canada, 100 Gamelin Blvd., Hull Que K1A 0H3. (Contributors: A.D. Tomlin, Agriculture And Agri-food Canada; Alain Baril and Christine Bishop, Canadian Wildlife Service, Environment Canada).
Status: ***COMPLETED; AVAILABLE FEB 1995*** **COESA Report No.: RES/MAN-009/94**

2.1 Literature Review of Methods Used to Conduct and Evaluate On-Farm Research
Contractor: Ms. Jane Sadler-Richards, Ecologistics Ltd, 490 Dutton Drive, Suite 1A, Waterloo, ON N2L 6H7
Status: ***COMPLETED, AVAILABLE JAN 1995*** **COESA Report No.: RES/FARM-001/94**

3.1 Development of Standard Methodologies: Resident Biomass and Organic Carbon
Contractor: Mr. David Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ON N1G 3M5
Status: ***TO BE COMPLETED MARCH 1995*** **COESA Report No.: RES/MON-001/95**

3.4 State of Resources: A proposal to Assess the State of Agricultural resources: Improving the Land Resource Database
Contractor: Mr. David Cressman, Ecologistics Limited, 490 Dutton Drive, Waterloo, ON, N2L 6H7 **Status:** ***COMPLETED, AVAILABLE, FEB. 1995*** **COESA Report No.: RES/MON-004/94**

3.5 State of Resources: Proposal for the Upgrade of Soil Survey Information in Oxford County
Contractor: Mr. D. Charlton, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ON N1G 3M5
Status: ***TO BE COMPLETED MARCH 1995*** **COESA Report No.: RES/MON-005/95**

3.6 State of Resources: Development and Application of Standardized Methodology for Sampling Soil Landscape Polygons
Contractor: Mr. J. Hagarty, Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ON, N1G 3M5
Status: ***TO BE COMPLETED MARCH 1995*** **COESA Report No.: RES/MON-006/95**

3.7 State of Resources: Development and Testing of "State of Agricultural Resources" A Reporting and Monitoring Methodology for Ontario.
Contractor: Mr. Harold Moore, Gregory Geoscience Ltd, Kanata Square, Suite 504, 260 Hearst Way, Kanata ON, K2C 2B5
Status: ***TO BE COMPLETED MARCH 1995*** **COESA Report No.: RES/MON-007/95**

AVAILABLE GREEN PLAN RESEARCH REPORTS

Please "check" those reports you wish to receive and return this form to:

Dr. Bruce T. Bowman
Pest Management Research Centre, Agriculture and Agri-Food Canada
1391 Sandford St., London, ON N5V 4T3

___ **1.1 Literature Search on Manure/Nutrient Management. Contractor:** Dr. Michael Goss, Dept. of Land Resource Science, U. of Guelph, Guelph, ON, N1G 2W1

___ **1.9 Literature Review on Wildlife Habitats in Agricultural Landscapes. Contractor**: Mr. Lyle Friesen, Canadian Wildlife Service, Environment Canada, 100 Gamelin Blvd., Hull Que K1A 0H3. (Contributors: A.D. Tomlin, Agriculture And Agri-food Canada; Alain Baril and Christine Bishop, Canadian Wildlife Service, Environment Canada).

___ **2.1 Literature Review of Methods Used to Conduct and Evaluate On-Farm Research. Contractor:** Ms. Jane Sadler-Richards, Ecologistics Ltd, 490 Dutton Drive, Suite 1A, Waterloo, ON N2L 6H7.

___ **3.4 State of Resources: A proposal to Assess the State of Agricultural resources: Improving the Land Resource Database. Contractor:** Mr. David Cressman, Ecologistics Limited, 490 Dutton Drive, Waterloo, ON, N2L 6H7.

___ **3.7 State of Resources: Development and Testing of "State of Agricultural Resources" A Reporting and Monitoring Methodology for Ontario. Contractor:** Mr. Harold Moore, Gregory Geoscience Ltd, Kanata Square, Suite 504, 260 Hearst Way, Kanata ON, K2C 2B5

___ **4.1a Maintenance Program for Three Southwestern Ontario Watersheds, 1993 - 94. Contractor: Mr. David Hayman, Upper Thames Conservation Authority,** R. R. #6, London, ON N6A 4C1.

___ **4.1b Maintenance Program for Three Southwestern Ontario Watersheds, 1994 - 95. Contractor: Mr. Ian Wilcox, Upper Thames Conservation Authority,** R. R. #6, London, ON N6A 4C1

___ **4.3 Influence of Soil Texture and Tillage Practices on the Susceptibility of Legume-N to Leaching. Contractor:** Dr. B.D. Kay, and Dr. V. Rasiah, Dept. of Land Resource Science, Univ. of Guelph, Guelph, ON N1G 2W1 *(LMAP funded project)*

___ **4.4 A Program to Assess Surface- and Groundwater Quality At Farm Sites Selected for Artificial Wetland Construction. Contractor:** Assoc. of Conservation Authorities of Ontario, 418A Sheridan Street, Peterborough, ON K9H 3J9 (Contact: Mr. David Hayman, Upper Thames Conservation Authority, R. R. #6, London, ON N6A 4C1) *(LMAP funded project)*

1996 Project Updates

1. *MANURE NUTRIENT MANAGEMENT & CLOSED LOOP RECYCLING*

Project Leader: Dr. Bruce T. Bowman

1.2 Nitrogen & Carbon Transformations in Conventionally-Handled Livestock Manures.

Contractor: Drs. G. Kachanoski and Dean Barry, Environmental Soil Services, 605 Arkell Rd., Arkell, ON N0B 1C0.

SUMMARY

The objective of the study is to quantify the changes in manure composition in different handling systems. The information will be used to make better predictions on the value/fate of the manure after application to land.

In the spring of 1995, manure and feed sampling was completed at a broiler farm producing solid poultry manure, and at the solid beef manure system for the cow-calf barn at the Elora Beef Research Centre. At Elora, manure samples were collected during field spreading to compare variations in rate and composition with that observed during spreading in the fall of 1994. Beginning in the early summer of 1995, detailed sampling began at two farrow-to-finish swine operations with liquid manure systems. One site is a privately run farm, while the other site is the swine unit at the Arkell Research Station. ESS is cooperating with the Manure Systems Group at the University of Guelph. Sampling of swine manure will continue until this spring, and includes rooms of different animal types, and medium and long term storage facilities. Emission of greenhouse gasses and NH_3 from slatted floors and manure in storage are being measured under summer and winter conditions, with the cooperation of G. Edwards of the School of Engineering. Rate of manure application during spreading in August from irrigation guns at Arkell was measured and gas emissions from the soil surface determined. Gaseous emissions from a fall application at Arkell are being monitored throughout the winter by C. Wagner-Riddle of the Department of Land Resource Science.

In January of 1996, sampling began on two dairy manure systems that will be the last systems studied by the project. One site is a solid dairy manure system at the Ponsonby Research Station. It involves daily manure collection by a gutter in the milking cow barn, and scraping in the heifer barn, followed by dumping on a covered manure storage pad. Part of the sampling will involve collection of manure from cows given two different diets, as part of a trial being conducted by Dr. B. McBride of the Department of Animal and Poultry Science. The trial will provide information on nitrogen use efficiency. Transformations of manure during storage and N mineralization when applied to the field will be measured. At the second dairy manure site, an alley flush system used for the milking cow barn is being studied. This system has three earthen lagoons used as storage and settling basins for recycling liquid manure used to flush the alleyways in the barn. Sampling of manure, feed, and gas emissions at both dairy manure sites will continue until the early fall of 1996.

An economic analysis of the manure systems included in this project is being conducted by Dr. P. Stonehouse. Much of the needed information has been collected, and analysis is well underway.

1.3 Manure Composting Techniques: Understanding Nitrogen and Carbon Conservation

Contractor: Mr. Richard St. Jean, Ecologistics Ltd, 490 Dutton Drive, Suite A1, Waterloo, ON N2L 6H7

Summary

Six composting experiments were conducted over the past year to compare the conservation of nitrogen, carbon and other nutrients relative to a variety of composting practices.

Three of the 6 composting experiments conducted were carried out at organic farming operations which currently compost their manure as part of their manure management program. Within the organic farming sector in Ontario, some, somewhat unconventional methods of composting are used. The intent of conducting experiments at these organic farms was to determine what measurable benefits in terms of carbon, nitrogen and other nutrient conservation could be identified and attributed to the manure characteristics or composting methods used. Three cooperator farms were selected that each use a different technique for composting their livestock manure.

The cooperator farms included a dairy operation, a dairy and beef operation and a mixed farming operation which had manures from dairy, beef, swine and horses. The dairy operation uses a modified static pile method, the dairy and beef operation uses a field windrow method and the mixed farming operation uses a process referred to as the Luptke Method.

In addition to the composting experiments on the organic farms, three composting experiments were conducted at a conventional farm site to examine relative differences in Carbon, Nitrogen and other nutrient conservation between composting under covered conditions, composting under open conditions and composting with barn yard runoff addition to the compost. These experiments were conducted simultaneously using beef cattle manure from a barn manure pack accumulated over 6 months. Each composting process used turned pile methods.

Raw manures and finished compost materials were sampled and analyzed for total nitrogen, ammoniacal nitrogen, nitrate nitrogen, nitrite nitrogen, phosphorus, potassium, total carbon, organic carbon, organic matter, ash, dry matter, pH, and carbon to nitrogen ratio. Germination tests were conducted on all finished composts using cress seed. The germination tests compared, germination in pure compost, a 50/50 compost soil mix, pure soil and dish germination. Compost temperature was monitored for all composting processes. On line monitoring of temperature, moisture, off gas composition and pore space gas composition was carried out at the conventional farm site.

1.4 Transformations in Soil: Crop Response to Nitrogen in Manures with Widely Different Characteristics

Contractor: Dr. E.G. Beauchamp, T. McGonigle, M. Goss and J. Buchanan-Smith, Department of Land Resource Science, University of Guelph, Guelph, ON, N1G 2W1

Summary

Field experimentation continued in 1994-95 on a different site than the previous year at the Elora Research Station. The objective was to determine the availability of N in several manures (100, 200, 300 kg N ha^{-1}) applied just before planting in comparison with urea fertilizer (50, 100, 150 kg N ha^{-1}). The manures, varying widely in N content as well as the proportion of the total N present as ammonium, included liquid swine (LS), liquid cattle (LC), solid cattle (SC) and solid poultry manures with straw bedding (P_S) or wood shavings bedding (P_W). The treatments also included additional straw or wood/shavings added to LC and SC (200 kg N ha^{-1}) applied the previous fall or just before planting.

In general, the corn crop response patterns in 1995 were similar to those for 1994. The following comments deal mainly with the 1995 results from field trials.

An additional component of the study was an assessment of the residual N in 1995 from different fertilizer and manure N treatments applied in 1994. Generally, there was evidence of a significant carryover effect of residual N and was related to the soil N test (NO_3^- level) determined in early May or early June. It was evident, however, that the ability of the soil N test to predict residual available N depended on the previous urea or kind of manure treatments.

In general, mineral N ($NO_3^- + NH_4^+$) (0-60 cm) levels in the fall, 1994, were increased by the fall-applied manure treatments especially with LC but only to a small extent with SC. Additional wood shavings or straw apparently had a negligible effect on mineral N levels in the fall. Mineral N levels tended to increase from net mineralization for about 25 days and then decreased for the remaining 25 days before winter, probably due to leaching and denitrification.

Following planting in May, 1995, the additional straw or especially wood shavings tended to depress mineral N with LC or SC for 60 days. The mineral N content (0-60 cm) pattern generally increased and then decreased during the latter part of this period as crop uptake increased. Mineral N content was evidently much lower with LC, for example, than with urea although similar quantities of ammoniacal N were applied. Thus apparent immobilization of mineral N occurred to varying extents with different manures especially if the proportion of NH_4^+-N of the total N was relatively low. Thus with SC, with 10 percent of the total N as NH_4-N, the addition of 300 kg N ha^{-1} resulted in a similar mineral N content as soil in the check plots. The uptake of N by corn seedlings up to 60 days following application of SC was actually lower than that on the check plots. Additional straw with spring-applied LC or SC had a greater adverse effect on mineral N availability than additional wood shavings. This was probably due to the greater decomposability of straw with concomitant immobilization of mineral N by soil microorganisms. There was little difference between P_W and P_S in this respect, however.

Grain yields tended to increase with increased N availability following urea or manure application. Relatively high responses were obtained with urea, LS, P_S and P_W whereas the lowest response was obtained with SC applied just before planting. In contrast, response to fall-applied SC was similar to other manure N treatments at 200 kg N ha^{-1}. Similarly, fall-applied LC tended to produce a yield similar to spring applied LC at the 200 kg N ha^{-1} rate. Recoveries of applied N by the above ground crop biomass were very low with all of the N treatments ranging from 50-75 kg N ha^{-1}. With SC, the recovery was about 25 kg N ha^{-1} in spite of application rates up to 300 kg N ha^{-1}.

The above results relate to the main focus of the project, phase 2. Crop response to N rates with P_S and P_W were done on the respective source farms (Phase 1). Briefly the data from these trials appear to indicate that mineral N and yield produced similar effects to those in Phase 2. Experimental work in Phase 4 involving manure N dynamics in acid soils has been completed but statistical analyses have not been completed yet.

1.5 Impact of Manure Application Methods on Water Quality, Focusing on Nitrogen and Bacteria Transport in Soil.

Contractor: Dr. G.J. Wall, B.A. Grant and D.J. King, Land Resource Unit, Harrow Research Centre
Agriculture and Agri-Food Canada, 70 Fountain St., Guelph, ON N1H 3N6

Summary

OBJECTIVES

1) Evaluate liquid manure application technologies in no-till (NT) corn cropping systems in terms of sustainable crop productivity and subsurface water quality (nitrogen and bacteria);
2) Identify pathways and processes of nutrient and bacteria transport to tile drains;
3) Develop liquid manure application recommendations for environmentally sustainable crop production.

METHODOLOGY

Three systematically tile-drained field sites in no-till corn production systems and contrasting soil textures (silt loam, sandy loam and clay loam) were selected for study. At each site a climatic station was established, and 12 parallel subsurface tile drains (100 m long) were intercepted and monitored for flow and water quality (NO_3,NH_4, fecal coliform bacteria) during the growing season (April-October). From the site soil and manure nutrient analysis, the manure application rate needed to meet the crop nitrogen (N) requirements was determined. A detailed crop monitoring program was initiated prior to planting to track weed pressure, plant population, crop disease, time to silking, lodging and yield. Draft and fuel consumption data between manure application methods were monitored by the AAFC instrumented tractor. Manure was applied using three application methods; (1) surface spreading, (2) conventional injection and (3) modified injection (loosening the soil ahead of the injectors). All treatment and control plots were replicated 3 times. Manure was treated with a chemical (strontium-chloride) tracer and bacteria tracer and applied in a 6m wide strip directly over the tile lines. Following manure application the tiles were monitored every 15 minutes and sampled for flow rate, nutrients, bacteria and tracer content for a period of three hours, after which an automated water sampler was used to collect samples at 3 hour intervals for 24 hours. On the day following manure application, the field was irrigated (2.5cm) using a travelling gun. Sampling was conducted at 15 minute intervals for the first 3 hours, then at 3 hour intervals for the following 24 hours. Sampling continued on a weekly bases for the remainder of the growing season.

PRELIMINARY FINDINGS

Water Quality

The preliminary results suggest that liquid manure applied at rates sufficient to supply the crop N requirements, on silt loam textured soils under NT systems can result in excessive levels of nutrient and bacterial contamination in the tile drain waters. Manure contaminants in tile drain waters within 5 minutes after manure application suggests downward movement by macropore (cracks and root channels) flow. In contrast liquid manure application on dry sandy loam textured soils (tiles not flowing) does not seem to result in excessive levels of nutrient and bacterial contamination in the tile drains, however, the simulated rainfall event resulted in tile water contamination within 15 minutes. Disturbance of macropores prior to liquid manure injection in NT fields seems to reduce the levels of contamination in tile drain waters following manure application and/or a rainfall compared to surface applied methods for both textured soils. The nutrient and bacteria concentrations exceeded the water quality standards for the first 48 hours after manure application and irrigation for all manure treatments, although both injection methods significantly reduce the amount of nutrients and bacteria reaching the tile drains.

Crop Monitoring

Soil fertility and manure analysis indicated that manure had to be applied at a rate of 5,400 and 6,400 gals/acre to meet the nitrogen requirements of the crop on the silt loam and sandy loam textured soils respectively. From a crop standpoint, the amount of nutrients lost through the tile drains would be insignificant (1-3%). The effect of the manure application methods on crop productivity was indiscernible from the control treatment under minimal fertilizer management.

Draft and Fuel Consumption Comparisons

The negligible differences in fuel consumption between the injection methods indicate that modified injection is an economically viable alternative for farmers. The increase in power requirements with the modified injection was less than 2L/ha over surface applied.

1.6 Closed Loop Recycling - Composted Biodegradable Organic Urban Waste Application on Agricultural Lands.

Contractor: D. Charlton (V. Alder), Ecolog. Serv. For Planning, 361 Southgate Drive, Guelph, ON N1G 3M5

Summary

The objectives are to evaluate the impact of the composted products on soil quality, crop growth and yields, and on surface and subsurface water quality. The main study consists of three field seasons of data collection - 1994 - 1996, with the project to be completed in 1997. Two trials were conducted during the 1995 growing season at one farm. The objective of one was to examine effects of compost application rates and timing on emergence and growth of corn and soybeans; the objective of the other was to examine effects of compost application on grass hay production.

Effects of rates and timing of compost application

In order to provide a more complete set of options for the management of compost material in agriculture, questions concerning its management - timing, rates, nitrogen relations, requirement for tillage - must be addressed. Compost application rates were approximately 100, 150, and 300 Mg ha^{-1} (as-applied) with moisture content approximately 50%. Applications were made in the fall, 1994, and the spring, 1995.

Effects on corn

There was no direct evidence that compost applications depressed nitrogen availability where N fertilizer was applied. Corn plant tissue sampling indicated nitrogen nutrition was not limiting yield; differences in yield between N-fertilized and unfertilized were similar for all soil treatments, implying a consistent effect of N fertilization for all treatments. Final plant stand was not affected by compost treatments. Plant counts made 1 wk earlier showed fewer plants emerged at the high rate of compost application and under spring- vs fall-applied materials, suggesting compost had some effects on the rate of seedling emergence. Plant development was accelerated at the highest rate of compost in the fall - a higher proportion of plants were at the fourth leaf on June 16 and reached silking one to two days earlier than other treatments. Plant development may have been inhibited under some spring compost applications - the low and high rates reached silking later than other treatments. Fall and spring applications had differing results on corn grain yields as well. Spring applied compost had no impact on grain yields, with or without N fertilizer applications. On the other hand, fall applications of compost produced higher yields, most consistently where N was applied but only at the high rate of application in the absence of nitrogen fertilizer.

Effects on soybeans

Soybean stand was improved by compost applications overall. Soybean plant measurements suggested a preference for fall applications over spring applications of compost. Compost appeared to accelerate development. Beans in bare soil and low rate compost treatments flowered later than soybeans under other treatments. Bean yields were clearly higher as the rate of compost application was increased. The improvement in yield as a result of compost applications is believed to be related to the increase in stand, the reduction in weed competition, and possibly improved moisture conditions. Nitrogen levels in the soybeans were generally adequate and there was no suggestion of interference of the compost application with N nutrition in the soybeans.

Application of compost to all grass hay

The objective of the experiment was to measure the yield responses of grass hay to a single spring application of compost, with and without supplemental nitrogen fertilizer. Compost application did not reduce hay production where nitrogen was applied. In fact greater response to the applied nitrogen was measured where the compost application was made. This response may be due to increased soil moisture conditions during the summer growth period where a deficiency of water may have masked the potential nitrogen response.

Main Trial

In the 2nd field season, compost reduced levels of ammonium and nitrate in soil solution extracted at 80 cm in April 1995 at both sites. Corn emergence was related to compost management at both sites. Final plant populations did not differ between compost applications and the controls. Corn grown with the compost silked one day earlier and produced higher corn yields than corn grown in the absence of compost at one site. At the other site, corn silked later and produced lower yields of grain corn under some of the treatments where compost was not incorporated into the soil. However, overall, there was no difference in yield between the corn receiving compost and corn in the controls.

1.7 Soil Organisms as Bioindicators of Agronomic Practices.

Contractor: Dr. A. Tomlin, Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St., London, ON N5V 4T3

Summary

Soil organisms have been shown to respond to agronomic practices such as crop selection, tillage practice and pesticide treatments in a predictable manner and as such, can be used to detect the general health of the soil as well as the direction of soil quality. As a result of biological activity in the soil, important differences can be detected in the soil structure, as well as in water and nutrient transport systems. Presently, the assessment of soil quality is limited to chemical and physical measures which do not account for the biological processes that play a major role in soil structure and function. The objective of this project is to measure the response of selected soil organisms as bioindicators of agronomic practices in southwestern Ontario, with the goal of using them in concert with the existing chemical and physical measures as both diagnostic and confirmatory tools of soil quality.

Data from two sampling seasons, 1994 & 1995, have been collected and analysed, with large observable differences appearing between conventional and no-till regimens within seven paired (conv-till/no-till) sites:

- changes in the numbers of earthworms *(Lumbricus terrestris* and *Aporrectodea turgida)* and levels of particular soil enzymes have displayed the greatest responses to tillage practices
- using tension infiltrometry, differences have been detected in pore structure classes between conventional and no-till; hydraulic conductivity is higher in conventional till below 5 cm soil depth
- soil organic matter and ^{137}Cs are accumulating in low slope positions in the watersheds at both soil surface and depth relative to mid and upper slope positions.
- a depletion of ^{137}Cs exists in the top 3 cm of no-till which was not observed in the conventional till; this may result from the dilution of ^{137}Cs with crop residue at the surface and/or from dilution with earthworm-transported material from below the plow layer
- fungal counts, respiration and phospholipid fatty acid analyses are in progress to measure microbial responses to tillage practices

Other components of this project include a spatial study at a National Benchmark site in Rockwood, Ontario which studies the variation of biological variables and how they are affected by physical and chemical properties, and landscape position. In Leamington, Ontario, a study is being conducted to test bioindicators to determine their response to differences in soil quality under intensive tomato cropping.

Another part of this project includes the analysis of orchard soils from the Okanagan Valley and in the Niagara region which were found to contain exceptionally high levels of DDT and lead. The results suggest that the residues are leaking into wildlife food chains via earthworms, even after nearly 25 years since DDT use ended.

1.8 Effect of Controlled Drainage/Subirrigation on Tile Drainage Water Quality and Crop Yields at the Field Scale.

Contractor: Drs. C. S. Tan, C. F. Drury, M. Soultani, H. Y. F. Ng , J.D. Gaynor and T. W. Welacky, Harrow Res. Centre, Agriculture & Agri-Food Canada, Harrow, ON, N0R 1G0

Summary

Nitrate leaching through the soil profile and contamination of ground water has become a serious environmental and economic problem for intensive agricultural systems. Using a field-drainage system for water table control adds a new dimension to farm management.
In Southwestern Ontario, field scale "on farm" demonstration sites were established by scientists at Agriculture and Agri-Food Canada, Harrow Research Centre in cooperation with three producers. A large scale study and demonstration of this nature, on producer land, raises farmer awareness and acceptance of this innovative technology. A controlled drainage (CD) system was established for soybean production on no tillage and conventional tillage sites on clay loam soil in a paired watershed whereas a controlled drainage and subirrigation (CDS) system was established for tomato production on a sandy loam soil. All three sites were instrumented to measure the volume and concentration of nitrate in tile drainage water and final yields. The objectives of this study were to determine the economic and environmental benefits of the system at the farm scale.

The total nitrate loss from May, 1995 to February, 1996 was reduced 40% from 6.7 kg N/ha for the drainage treatment (DR) to 4.0 kg N/ha for the controlled drainage treatment (CD) under no tillage soybean field. During the same period, the total nitrate loss was reduced 36% from 0.59 kg N/ha for the DR treatment to 0.38 kg N/ha for the CD treatment under conventional tillage soybean field. Both the CD and DR treatments had similar flow weighted mean nitrate concentration of tile drainage water on the two soybean fields. The total tile drainage volumes were reduced 36 to 40% with CD compared with the DR treatments under conventional tillage and no tillage soybean fields, respectively. There were no significant differences in yields between the CD and DR treatments for two soybean fields due to dry growing season in 1995. The average soybean yields were 3.3 t/ha for no tillage field and 3.7 t/ha for conventional tillage field. The controlled drainage and subirrigation (CDS) treatment reduced tile drainage volumes by 44% and total nitrate loss by 43% when compared to the DR treatment under tomato production. The marketable tomato yields were 64.9 t/ha for the CDS treatment and 58.4 t/ha for the DR treatment. The CDS treatment increased marketable tomato yields by 11%. Unfortunately, the farmer was unable to harvest these tomatoes at the optimal time and a large amount of tomatoes in the CDS treatment were over ripe. Hence potential yields increase realizes with the CDS treatment may be 25 % greater than the DR treatment with optimal management. Thus, the controlled drainage and subirrigation system can effectively reduce total nitrate loss and improve the crop yields if subirrigation water is available during dry periods in the summer.

1.10 Assessment of the influence of manures for the control of soilborne pests including nematodes, fungi and bacteria.

Contractor: Dr. George Lazarovits and Ken Conn, Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St, London, ON, Canada, N5V 4T3.

Summary

BACKGROUND

Organic amendments such as manures provide great improvements to soil in the form of organic content, water retention, biological buffering, and nutritional balance. Potato growers however are reluctant to use manure because of the fear that it will increase the incidence of potato scab, a disease caused by bacteria belonging to the genus Streptomyces. The impact of manures on the other major soilborne disease of potatoes, Verticillium wilt caused by the fungus Verticillium dahliae, is also unknown. In tests with other types of organic amendments we have shown that these two pathogens are excellent model systems for studying the impact of organic materials on reductions or increases of disease caused by soilborne pathogens in general.

OBJECTIVE

The objective of this study is to determine if manures and related organic materials can be applied to soils used for potato production in a manner that will maximize positive effects (e.g. reduction in disease, increased yield, and better soil quality) while minimizing negative effects (e.g. higher disease incidence and toxic effects).

RESULTS

Soil type effects the impact of manure on pathogen populations in soil.

Straw and wood-based chicken manures reduced the germination of V. dahliae microsclerotia in Simcoe and Everett soil but had no effect in London soil. Liquid swine and dairy cattle manures reduced the germination of V. dahliae microsclerotia in Everett soil but had no effect in Simcoe or London soils. Thus, all the manures tested were able to reduce the viability of V. dahliae in at least one of the three soils tested but not in all the soils.

Wood and straw-based chicken manures increased the Streptomyces population in all three soils. Liquid swine and dairy cattle manures increased the Streptomyces population in Simcoe soil which then declined back to the control level, and had no effect in Everett or London soils. Thus, chicken manures appear to have a potential for increasing potato scab while liquid manures may be safe to add to soils where potatoes are to be grown.

Soil moisture effects the impact of manure on pathogen populations in soil.

The dryer the soil the greater the reduction in germination of V. dahliae microsclerotia when liquid swine manure was added to Everett soil. For optimal reduction of Verticillium wilt liquid swine manure should be added to Everett type soils under dry conditions. However, the dryer the soil the larger the increase that occurred in the population of Streptomyces for wood-based chicken and liquid swine manures. Thus, adding these manures to Everett soil under dry conditions may increase potato scab and reduce wilt. When applied under moist conditions the opposite effects may result.

Development of an assay to test the impact of manure on pathogen populations in soil.

We are well on our way to developing a rapid and reproducible assay for determining whether a particular manure is safe to put onto a particular soil. This will enable us to provide farmers with information as to where certain manures can be safely applied and under what conditions.

1.11 Measuring (Changes in) Soil Microbial Populations by Analysis of Their Phospholipid Signatures.

Contractor: Dr. Ralph Chapman & Ms. S. Millar, Pest Management Research Centre, Agriculture and Agri-Food Canada, 1391 Sandford St, London, ON, Canada, N5V 4T3

Summary

The objective of this project was to determine the feasibility of using chemicals naturally produced by soil microbes as indicators of changes in the soil microbial community structure resulting from different, common agronomic practices.

The behaviour of soil microorganisms is of fundamental importance to agriculture. Traditional microbiology techniques for studying soil microbes are limited to those organisms that are culturable on nutrient media. The magnitude of this limitation is not known, but some estimates have suggested as few as 1% of the microorganisms present in soil grow when transferred to culture media. Measures of microbial community structure that are not limited by culturability would improve our capability for studying soil microbes.

One suggestion is to measure the concentration of chemicals which are extractable from soil and are characteristic of the microbes present. Phospholipids are a constituent of all living cells and are rapidly degraded on cell death. Their chemical composition can vary markedly between microbial species and genera, but is relatively constant for a species when grown under controlled conditions. These properties make phospholipids a good candidate for an indicator of microbial community structure.

Phospholipids were extracted from soils taken from fields with different cropping, fertilization and cultivation histories. Their composition was determined using two different methods. Nuclear magnetic resonance spectroscopy based on phosphorus (31-P NMR) was used to analyze for phospholipid class composition and the constituent fatty acid composition of the phospholipids present was determined by capillary gas chromatography.

Small but significant differences were observed in the fatty acid composition of phospholipids from soils under continuous tomato and wheat / soybean / tomato rotational culture. Significant differences were also observed between high and low fertilizer treatments within the two cultural methods. Phospholipid class composition was found to vary among eight soils tested from four paired till / no-till sites, but none of the differences appeared to be consistently associated with a tillage practice.

2. *ON FARM RESEARCH*

Project Leader: Dr. Al Hamill

2.2 Investigating Methods of Integrating Liquid Manures into a Cropping System and the Effect on Soil and Water Quality.

Contractor: Mr. David Charlton (George Schell), Ecolog. Services For Planning, 361 Southgate Drive, Guelph, ON N1G 3M5

Summary

The liquid manure project is a series of ongoing research experiments on field length plots at farm sites in southwestern and eastern Ontario. Ecological Services for Planning is managing the project along with two research partners, REAP-Canada and Ag-Knowledge.

The objectives of the project are to evaluate the influence of manure application rate, timing and technique on corn growth and soil nutrient content in a conservation tillage system. The research is funded by the Canada-Ontario Green Plan. Green Plan research activities are designed to promote environmentally sustainable agriculture within the farming community.

The 1995 field season was the second of three years of field studies and data collection. Experiments continued at the same farms in southwestern Ontario (one dairy farm and three hog farms) and in eastern Ontario (a poultry farm and a dairy farm). The management systems practised at the six farms include no-till, Aerway tillage, chisel tillage and ridge tillage.

The experimental treatments included the application of 100% of the estimated nitrogen requirement from manure, 100% from inorganic fertilizer and a combination of approximately 75% of the nitrogen requirement from manure and 25% from inorganic fertilizer. The effect of the timing of manure application was evaluated through comparisons of treatments involving preplant and side-dress manure applications, or two different side-dress application timings. Manure was applied by a tanker in all cases, and incorporation was achieved using either the Aerway tillage implement (pre-plant applications) or a disk. The inorganic fertilizer treatments were applied either as a starter with the planter or as a side-dress application.

The effect of the treatments on the nutrient status of the soil was evaluated through soil fertility and soil N tests in spring and fall. The agronomic effects of the different manure and inorganic N treatments were evaluated through measurement of ear leaf nitrogen, final corn yield and weed counts at some of the sites.

Results in 1995 indicated that liquid manure can be used as an effective substitute for commercial nitrogen sources in minimum tillage corn production systems. On clay loam sites, a starter fertilizer appears to be required to maintain productivity levels. Liquid manure application has resulted in increased weed pressure at some of the sites compared to inorganic fertilizer sources.

The timing of manure application (pre-plant versus early or late side-dress) showed no significant effect on yield. This finding is encouraging, for it demonstrates that with proper equipment, the window of opportunity for the application of liquid manure extends from the pre-plant stage until the corn crop is at the 6 to 7th leaf stage.

Fall soil nitrate tests indicated no significant difference in the amount of residual soil nitrate for treatments receiving nitrogen in the form of a manure application or as inorganic fertilizer. This finding will be examined in greater detail in the final crop season of the experiment. Preliminary indications are that the use of moderate rates of liquid manure does not result in an excessive accumulation of nitrate in the soil.

The results of the first two years of this experiment indicate that manure can supply nutrients at comparable rates to inorganic fertilizers, with no increase in the amount of nitrate that is available for leaching into the groundwater in the fall. However, the management of manure in a conservation farming system poses additional challenges, such as weed control. This and other challenges relating to effective manure management on conservation farms will be investigated in greater detail in the final year of field studies for the liquid manure project.

2.3 Environmental Effects of Conservation and Conventional Cropping Systems.

Contractor: Ms. Jane Sadler-Richards, Ecologistics Ltd, 490 Dutton Drive, Suite 1A, Waterloo, ON N2L 6H7

Summary

This three year research study is designed to compare the environmental effects of conservation and conventional cropping systems. The current project is funded by Agriculture and Agri-Food Canada through the Green Plan Program.

It has become evident that conventional cropping systems produce some serious off target environmental concerns such as soil erosion (Hausenbuiller, 1985) and contamination of ground and surface waters by agricultural chemicals (Hallberg, 1987; McDowell et al., 1984; Hubbard et al., 1982; Baker et al., 1982; Baker and Johnson, 1979).

Since the early 1980's, there has been a significant increase in the use of conservation tillage by producers. While the move towards conservation cropping systems has been a positive trend, there is some concern about the full environmental impact of the newly adopted systems. Several studies have indicated that conservation tillage systems, particularly no-till systems, can have elevated nutrient and pesticide losses (Barisas et al, 1978; Baker and Johnson, 1979; McDowell and McGregor, 1980).

Such studies lead to the question: Are we solving one problem (i.e. soil erosion), but creating another (nutrient and pesticide leaching)?

In the main study, fields have been selected from farms which represent viable production systems where respective conservation or conventional production systems have been in place for a minimum of four years. the compared production systems include a no-till system and a conventional (moldboard plough) system which have a corn/soybean/winter wheat rotation. Eight paired fields (16 fields total) have been selected based on their similar soil type, drainage, slope, geographic area, cropping rotations, cropping inputs and cooperator willingness to participate.

Selected soil and water quality parameters have been monitored since spring 1994, with a focus on pesticide and nutrient movement. Monitoring is occurring on a seasonal and rainfall event basis four times per year for three cropping years. Input/output data on two production systems is also being collected to allow for an economic analysis. An additional large and independent study on "Soil Organisms as Bioindicators of Agronomic Practices" is also underway at these sites.

The findings of this study will be available in early 1997.

2.4 Determining the Factors Responsible for, and Methods to Overcome the Limitations of Conservation Cropping Systems on Clay Soils

Contractor: Drs. T.J. Vyn and C.J. Swanton, Crop Science Building, University of Guelph, Guelph, ON, N1G 2W1

Summary

Objective D

To evaluate the impacts of a cereal cover crop and reduced tillage systems on weed management strategies for soybeans grown on clay soils

Combinations of rye cover crop and broadcast or banded herbicide treatments were compared in wide and narrow row no-till soybeans at sites near Alvinston and Southwold.

Common ragweed was the predominant species at both locations, accounting for approximately 86% of the total uncontrolled weed population. A total of 240-280 ragweed seedlings m-2 emerged during the season at both sites. Emergence of these seedlings occurred early in the season, approximately 80% of all ragweed seedlings had emerged by May 18, when a preplant glyphosate burn-down was applied.

The presence of rye residue had no detrimental effect on soybean emergence, growth and development, or crop yield at either location. Weed biomass was also unaffected by the presence of rye residue.

Soybeans grown in narrow rows gave significantly greater weed suppression than soybeans grown in wide rows. When glyphosate alone was applied as a preplant burn-down, weed biomass was reduced by 70% when soybeans were grown in 19 cm rows, but by only 50% when grown in 76 cm rows. Soybeans grown at higher populations in narrow rows produced a more developed leaf canopy than wide row soybeans. Under the narrow row canopy, 56% less photosynthetically active radiation was available to weeds than under the wide row soybean canopy.

The use of broadcast preemergence or postemergence applied herbicides, following the glyphosate burn-down, provided a further 30% in weed control in narrow row soybeans. Although these additional control measures increased narrow row soybean yields by 20%, yields with glyphosate alone were similar to those obtained with the most effective treatments when soybeans were grown in wide rows. In wide rows, cultivation increased weed control by 22% and provided an 18% soybean yield benefit. The use of banded preemergence applied herbicides combined with cultivation, gave 91% control of weeds and soybean yields similar to broadcast herbicide treatments.

2.5 To Obtain Information on Variable Rate Technology for Nitrogen Application and Determine the Feasibility of Implementing this Production Tool

Contractor: Dr. Gary Kachanoski, Dept. of Land Resource Science, U. of Guelph, Guelph, ON N1G 2W1

Summary

The goal of this study is to determine the feasibility of variable rate technology for N fertilizer application, to maximize economic crop response while minimizing environmental impacts on water quality.

Specific objectives include (1) To assess different methods of obtaining the field map for variable application of fertilizer N, (2) Determine the economic benefits of variable application of N fertilizers, and (3) Determine the change in potential nitrate loading to the groundwater from variably applying N fertilizer.

Two sites established in the spring of 1993 in Huron Co. near Londesboro, Ontario on the farm of Bruce Shillinglaw. Each site consisted of 4 adjacent blocks of no-till planted corn. Each block consisted of: (1) Fertilizer added (F) @ 160 kg N/ha, and (2) No fertilizer N added (NF). Spatial patterns of yield with fertilizer added and yield with no fertilizer were obtained from detailed hand harvesting and a commercial on-the-go yield sensor attached to a combine. All measurements are referenced to detailed elevation maps of each site obtained from a laser theodolite survey.

The data from the first year of results was used the next year to construct two variable rate maps for fertilizer N application for each of the two sites (S1, S2). The 2 variable rate maps were based on 1) the N soil test and 2) a differential yield map (fertilizer yield - check yield). In 1995 the sites were planted to soybeans over the previous treatments. Crop yields were taken by hand at similar locations as corn in the past 2 years. Soil N tests were again taken, and estimates of soybean nodulation obtained. The yield measurements with the on-the-go yield sensor were highly correlated (r=0.92) to hand sampled yields. The only problem encountered with the sensor was a minimum yield requirement of approximately 1.8 t/ha for the sensor to work. Increases in yield from applied fertilizer N varied from essentially zero to over 3500 Kg grain/ha. Fertilizer N requirements within the field varied from 0 to 170 kg N/ha. The variability was not random and was significantly correlated to topography. The check yields (ie yields with no fertilizer N) from 1993 and 1994 were highly correlated, but the check yields are mostly lower in 1994. This was expected since the 1994 sites have had no fertilizer for 2 years compared to only one year for the 1993 check yields. The soil has an N pool that becomes available in the time scale of 1-3 years.

The variable rate application of fertilizer N based on the ΔY_F map resulted in 98 kg N/ha (average) being applied (ranging from 0 Kg N/ha - 150 Kg N/ha) compared to 150 Kg N/ha in the continuous. The soil test map indicated only 68 Kg N/ha were needed. Variable rate N using the ΔY_F map resulted in 0.30 t/ha less grain worth $36.00/ha @ $0.12/Kg), but used 52 Kg/ha less N fertilizer for an input savings costs of $40.00 @ 0.77/Kg/N). The soil test map lost a significant amount of yield that was not economic based on N fertilizer savings. Constant rate application resulted in 34 Kg/ha more N applied as fertilizer than is taken off the field as N in the grain. Variable rate application based on ΔY_F resulted in 13 Kg/ha less N applied as fertilizer than is taken off the field (as N in the grain). Measurements of soybean yields on the old treatments indicate some carry over effect. The soybean yields on areas that had 0 fertilizer 2 years in a row were on average 3-5% lower than those sites that were continuously fertilized. This indicated that differential management must be applied also for soybean and that this management cost must be included in the costs of variable rate application. The sites are scheduled to be planted with Barley this spring with zero and full fertilizer N treatments.

2.6 Measuring the Effect of Crop Residue or Live Cover Crops in Conservation Tillage Systems on Soil and Water Quality.

Contractor: Dr. C.F. Drury, Dr. C.S. Tan, Mr. T.W. Welacky, Dr. T.O. Oloya, Dr. S.E. Weaver and Dr. A.S. Hamill, Harrow Research Centre, Agriculture and Agri-Food Canada, Harrow, ON NOR IG0

Summary

Widespread adoption of no-tillage systems for soybean and winter wheat production has occurred in Ontario. This has resulted in reduced fuel and labor costs by eliminating fall plowing, and has also reduced soil erosion by maintaining crop residue on the soil surface during the fall to spring periods. Unfortunately, no-tillage systems have not been as successful for corn production systems. This is a serious problem as corn is commonly used in a rotation with wheat and soybean. Furthermore, when corn follows winter wheat under seeded to red clover, there may be an additional problem associated with residue management during the early stages of corn growth. The objectives of this project were to determine the effects of no-tillage systems on soil physical (temperature, moisture, structure), biological (microbial biomass, soil respiration) and chemical (nitrogen cycling) properties and to identify the problems associated with planting corn into wheat stubble. With this knowledge, alternative management systems would be investigated to reduce these problems and provide Ontario farmers with technologies that would enable them to adopt conservation tillage systems for corn, soybeans and winter wheat.

Treatments included conventional versus no tillage both with and without red clover in a wheat-corn-soybean rotation in a clay loam soil. Results have been determined in the corn year of the rotation. To date, no- tillage has increased mean weight diameter (MWD) of soil aggregates and improved their wet aggregate stability (WAS). The inclusion of red clover with the conventional tillage improved WAS. There were no noticeable differences in soil bulk density between treatments. No-tillage increased soil water content in the top 30 cm soil profile. Red clover with conventional tillage also increased soil water content compared with conventional tillage bare treatment. No-tillage reduced soil temperatures at 5 cm depth by 2-3^{0}C in June compared with conventional tillage. The differences in soil temperatures were diminished from July onwards. Red clover did not effect the soil temperatures in conventional tillage treatments but decreased soil temperature by about 0.5 ^{0}C in no- tillage treatments.

The soil respiration rates were 45% greater in conventional tillage than no-tillage treatments. Hence, residue decomposition was considerably greater with the conventional tillage treatments. Red clover treatments from the previous year did not have a significant effect on soil respiration rates. In 1995, the conventional tillage treatments resulted in excellent corn yield (9.5 t ha^{-1}) which was about 16% greater than yields in the no-tillage treatments (8 t ha^{-1}). Nitrogen uptake in the corn grain was also considerably greater with the conventional tillage treatment (101 kg N ha^{-1}) compared to the no-tillage treatment (80 kg N ha^{-1}). There were several factors that contributed to the yield reduction with no-tillage treatments in 1995. Rainfall was only half the normal amount after planting until late June, most of which was received in one event on June 27 which resulted in drought conditions for early emergence and plant establishment. In the no-tillage treatments, soil drying occurred along the planting slot which enabled the soil to open and the corn seedling to become water stressed; even though the average water content in the no-tillage treatments was greater than the conventional tillage treatments. In addition, cooler temperatures also reduced emergence rates and early crop growth. The net result was that the corn in the no-tillage treatments was significantly delayed and was never able to catch up to the corn in the conventional tillage treatments.

In summary, there were many benefits to the no-tillage treatments including improved structure and lower soil respiration rates. However early season moisture must be managed better for the corn to get optimal advantages from these soil properties. In the next phase of this project starting in the fall of 1996, zone tillage will be examined as a means of improving the conditions in the zone surrounding the young corn seedling. In this manner, it is hoped that the corn can take advantage of both the soil improvements associated with a reduced tillage system while maintaining high yields.

2.7 Crop Rotations and Cover Crop Effects on Erosion Control, Tomato Yields and Soil Properties in Southwestern Ontario

Contractor: Mr. R. W. Johnston, Horticultural Soil Management, Ridgetown College of Agricultural Technology, Ridgetown, ON NOP 2C0

Summary

The six year average (1990-1995) of red tomato yields (marketable) indicates that the best four crop rotations increased production 23.4 and 43.1% respectively at Leamington and Dresden compared to continuous culture (Figure 1). Tomatoes in five out of nine crop rotations yielded in excess of 60 t/ha with no nitrogen fertilizer in 1995. Compare this to a yield of 8 t/ha or less in 1989. Continuous tomato culture would be very similar to intensive vegetable production. Continuous tomato yields remain relatively static at Leamington while at Dresden continuous tomato yields have decreased from 41 t/ha to 27 t/ha in 1995.

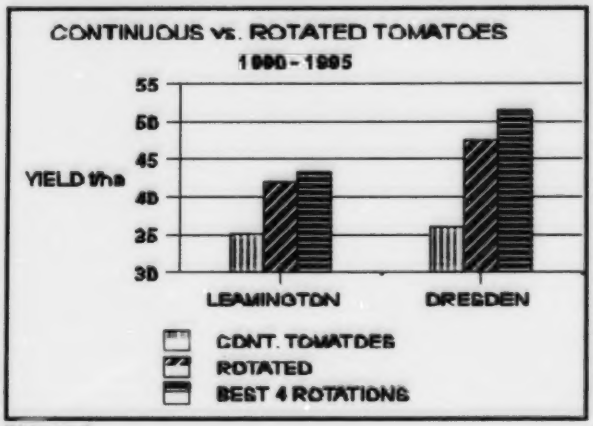

Figure 1.

Crop rotation has increased the number of earth worms significantly over continuous tomato culture. Of the twelve soil organisms monitored by Agriculture and Agri-Food Canada personnel in London, nine of these organisms have increased dramatically with crop rotations containing high residue crops or legumes. Organism counts were higher at the Dresden location. Total nematode counts were lowest in continuous tomato culture at both locations. Crop parasitic nematodes (lesion and root lesion) were lowest in continuous culture and highest in those rotations containing legumes particularly red clover at both locations. Parasitic nematodes were highest at Dresden with the counts being as much as nine times the critical level of 1000/kg of soil. Interestingly this situation occurred on some of the highest yielding rotation.

Crop rotations have resulted in a consistent but not large change in tomato quality. Redclover as measured by Agtron is 2-4 points lower following the best rotations. Soluble solids and total solids (limited data) have increased from 0.2 to 1.0% following crop rotation. It is rare that yield, colour and solids all increase together.

Soil samples taken for bulk density, soil organic matter, organic carbon, and wet aggregate stability have shown that crop rotations have:

(a) significantly lowered soil bulk density
(b) increased soil organic matter
(c) increased organic carbon slightly but consistently
(d) increased soil nitrogen
(e) increased soil moisture holding capacity slightly at one location
(f) increased wet aggregate stability compared to continuous tomato culture.

Observations after several heavy rains has indicated that soil drains more rapidly in crop rotation than in continuous tomatoes or soybean-tomatoes. Measurements with a Guelph Permeameter indicate the infiltration rate of soil has been increased significantly by rotation. The computer equipped tractor of Agriculture and Agri-Food Canada indicates some significant differences in horsepower to pull various implements and fuel consumption.

At both locations, grass weed escapes are greatest following alfalfa and redclover. In plots with a rye cover crop, (CT and CuGBT) there are few weed escapes until just before harvest in Aug[illegible]. The cover crop project has complimented the rotation project indicating tomato yields increase significantly with crop rotations. Also, where no cover crop is compared to a cover crop, tomato yields are increased from 2 to 7 t/ha. Soil erosion (observation only) has been reduced by increase soil cover with crop residue and improved soil structure.

3. *DEVELOPMENT OF AN INTEGRATED RESOURCE MONITORING CAPABILITY*

Project Leader: Dr. Bruce MacDonald

3.2 Development of Standard Methodologies: Resident Biomass and Organic Carbon

Contractor: Dr. Gary Kachanoski, Environmental Soil Services, 605 Arkell Rd., Arkell, ON N0B 1C0.

Summary

The objectives of this project are (1) to develop and test methodologies to measure resident biomass and organic soil C, (2) to characterize forms and spatial and temporal variations of soil C sufficient to distinguish a 20% change over and above seasonal and random variations, and (3) to relate the soil C measurements to other soil properties.

The study makes use of extensive information already collected as part of the Tillage-2000 project. A total of 150 Ap horizon soil samples were selected from the Tillage-2000 benchmark monitoring locations. The samples represent 75 soil landscape positions each split into a conservation and conventional tillage system. The samples have detailed back-up information already available. Analyses carried out as part of this project include; Light Fraction C and N, Macroorganic C and N, total C and N, potentially mineralizable C and total mineral N. In addition , a subset of 20 Ap horizon soil samples were selected for detailed chemical analyses using 13C-NMR and GC-MS. These detailed analyses are being completed by Dr. E. Gregorich, CLBRR, Agric. Canada (Ottawa), and Dr. M. Goss (Univ. of Guelph).

Detailed statistical analysis of the relationships between the different indices of soil C and N were carried out to determine which measurements are necessary to characterize the current state of the soil, so that future monitoring can be carried out. Field measurements were taken over 2 years to characterize the spatial and temporal variations in soil C at the Lobb farm (Huron Co.), which has a sand to sandy loam textured catena sequence and a silty clay-loam to clay-loam catena sequence, and the Pottruff farm (Brant Co.), which has a loam catena sequence. Each catena sequence has three benchmark monitoring locations; upper (eroded), middle (transitional), and lower (depositional). Sampling was based on soil horizons to obtain a measure of the solum specific mass (i.e. the amount of C and N per unit land area from the surface to the depth of the pedogenic B/C interface). Sampling times were set to characterize major crop growth stages. Separate measurements of soil bulk density and horizon thickness were obtained for each of the samplings. The above ground crop biomass C and N at time of harvest was also sampled.

All plant and surface residue samples were analysed for total C and N. Soil samples were analysed for organic C, Total N, mineral N, microbial biomass C and N, and macroorganic matter C and N. Estimates of the accuracy of measurements is given.The data indicate that erosional processes are controlling the "state of the soil resource" and this translates into significant spatial differences in both the long term carbon storage in the soil and short term above ground plant biomass C production. The relative difference in yields were quite similar to the relative differences for both 137-Cesium and total organic C in the solum. Cesium-137 may be a very easily measured useful Agro-environmental indicator.

3.3 Development of Standard Methodologies: Bio-indicators and Methodologies to Quantify Soil Quality - Sensitivity of soil enzyme activities to management-induced changes in soil quality.

Contractor: Dr. C.M. Monréal and D.W. Bergstrom, Centre for Land and Biological Resources Research, Agriculture and Agri-Food Canada, Central Experimental Farm, Ottawa, ON K1A 0C6

Summary

The objective of our project is to use measurements of soil biochemical properties as indicators of soil quality.

Data were presented to illustrate sensitivity of enzyme activities to management-induced changes in soil quality. Six soil enzyme activities (dehydrogenase, urease, glutaminase, phosphatase, arylsulfatase and -glucosidase) were measured. At a site near Rockwood, samples of the Ap horizon were collected from no-till and conventionally tilled fields on a simple, single slope averaging 4%. Enzyme activity measurements made on field-moist samples collected over the growing season were compared with Vmax estimates obtained from kinetic analysis of air-dried samples. Both kinds of measurements indicated that, on average, enzyme activities were greater in the no-till field. Yet, sampling depth, slope position and time of sampling also affected enzyme activities, and influenced comparison of management practices.

At a second site near St.-Isidore, we assessed the effect of poultry manure on soil enzyme activities. Manure application markedly increased NH_4^+ and NO_3^- content of surface (0-8 cm) soil, and also increased dehydrogenase, urease and phosphatase activities. The increase in enzyme activities was transient, and did not persist through the growing season. Moreover, there was appreciable seasonal variation in enzyme activities that was unrelated to manure application.

At a third site near Clinton, tillage practices (no-till vs. conventional) were compared on fine and coarse textured soils. For fine textured soil, there was no difference in organic C content between the two tillage practices. Yet, no-till soils had greater activity of phosphatase and arylsulfatase in the Ap horizon; and greater dehydrogenase activity in the surface (0-8 cm) soil. Thus, in fine textured soil at the Clinton site, enzyme activities were more sensitive than organic C content to tillage practices.

While enzyme activities were sensitive to management practices at all sites, additional knowledge about the ecological meaning of the soil enzyme activities is needed to use them as measurements of specific soil functions. Likewise, new approaches are needed in interpretation of these measurements to use them in soil quality assessments.

3.8 State of Resources: Monitoring Soil Loss and Redistribution Using ^{137}Cs

Contractor: Dr. Gary Kachanoski and A.P. vonBertoldi, Environ. Soil Services, 605 Arkell Rd., Arkell, ON N0B 1C0.

Summary

Atmospheric fallout of ^{137}Cs occurred throughout the world in the early 1950's and 1960's from above ground testing of nuclear weapons. The ^{137}Cs was incorporated into the topsoil by tillage and strongly adsorbed to soil particles. Thus, the movement of soil can be tracked with time by monitoring the redistribution of ^{137}Cs. The two major objectives of this project are: (1) Construct a map of baseline ^{137}Cs (total deposition, Bq m-2) values for South-Western Ontario, and (2) Determine the redistribution of ^{137}Cs/soil since 1965 within a watershed typical of Ontario conditions, including deposition within the watershed, export out of the watershed, and loss from the uplands.

A total of 40 sites were selected for baseline ^{137}Cs on the basis of availability of long-term precipitation records and geographic position. At each forested site two composite soil samples were obtained and analysed for fallout ^{137}Cs. Approximately 82% of the variability of the ^{137}Cs values was accounted for by differences between sampling locations, and only 18% of the variability was attributed to within site variability. The ^{137}Cs values ranged from 1861 to 3015 Bq m^{-2}. A baseline map of ^{137}Cs fallout has been constructed. The sub-basin of the Kintore watershed was chosen as the site for objective (2). In cooperation with the Upper Thames Conservation Authority, land owners within the basin were contacted and agreed to allow measurements. Sampling was stratified to characterize fields as well as major landforms. Each sampling benchmark for ^{137}Cs was surveyed with a laser theodolite, and numerous other points were also surveyed for elevation. At a ^{137}Cs sampling benchmark, 9 soil cores (3.175cm diam.) were taken in a 3 x 3 sampling grid (3m intervals for a total area of 6m x 6m). The middle sampling point was centered on the laser theodolite location. Each of the cores were sliced at the bottom of the A- horizon, and then bulked to form a single composite sample for the benchmark and for subsequent analysis of ^{137}Cs. More than 350 soil landscapes were measured for ^{137}Cs, A-horizon thickness, and bulk density.

A map of the ^{137}Cs distribution in the sub-basin is being finalized along with a mass balance estimate for losses. A detailed soil map has been digitized and combined with the digital topographic information. The influence of soil and landform combinations on ^{137}Cs redistribution has been calculated. All of the information has been geo-referenced for future studies.

3.9 Development and Application of a Computerized System to Manage, Use and Distribute Data Collected by Green Plan Monitoring Research Projects

Contractor: Mr. Ken Denholm, Fenghui Wang, Bruce MacDonald and Bev Boulay
Ont. Land Resource Unit, Agriculture and Agri-Food Canada, 70 Fountain Street, Guelph, ON N1H 3N6

Summary

The overall objectives of the study were to:

1) develop a data management and analysis system with the capability to correlate, interpret and document linkages between the data collected through Green Plan research projects;
2) carry out data and spatial analysis to verify the content and quality of digital data received from the Green Plan Monitoring component;
3) provide standardized, documented copies of data for assessment and use by other projects and agencies and for comparison with future measurements.

Projects within the Green Plan Monitoring component deliver data and maps in digital formats in addition to the standard paper reports. This data management project deals with Green Plan projects with digital data as well as location and summary information for other Green Plan research projects and with other components of the AAFC Green Plan.

The accomplishments to date include an enhanced data management system operating on a UNIX platform running Arc/Info located at the Ontario Land Resource Unit (OLRU) in Guelph, Ontario and the development of a procedure to review and evaluate digital data in a rigorous fashion comparable to the review process normally applied to printed reports. The OLRU can now receive and integrate data from Green Plan projects into the database management system consistent with the Canadian Soil Information System and National Soil Data Base (CanSIS/NSDB) standards. As well, a protocol for assessing and evaluating the incoming Green Plan digital data using the OLRU data model has been developed and is presently being tested.

Briefly, the procedure for assessing the quality of data is as follows:

1) Review and Classification - assessing the suitability of data to be included in the Ontario Soil Data Base (OSDB) and whether this digital data agrees with the final report;
2) Review of the detailed work plan - did the contractor meet the original terms of the agreement?
3) Test the data with the OLRU data model - includes a standard Arc/Info check of the consistency and quality of the data and determines how much extra effort is required to bring the data up to standard;
4) Review metadata and metadocuments - tracing and documenting the nature, quality and origin of the digital data which determines the accuracy and confidence that can be associated with the data.

Complete metadata records, accessed through a convenient interface, provide the user with the capability to find data in the system and document the nature, quality and origin of the information. These components of the data management system become increasingly important as the quantity and variety of information expands. An interactive metadata interface system has been developed and is now in the testing stages. The metadata interface provides data users with an easy, interactive online way to access metadocuments through the Agrinet. The potential for having metadata and metadocuments available on the Internet using web technology is quite promising and will be explored in the immediate future.

3.10 Partitioning of Solutes from Agricultural Fields within the Hydrologic System at Two Sites in Southern Ontario and the Subsequent Impact on Adjacent Aquatic Ecosystems

Contractor: Dr. David Rudolph (Kachanoski, van Wesenbeeck, Barton), Waterloo Centre for Groundwater Research, University of Waterloo, Waterloo, ON N2L 3G1

Summary

The first objective of this study is to determine the main transport pathways of nitrate fertilizer and herbicide from a working farm field to a surface drainage ditch. Secondly, we are investigating the impact of the farm field on the biological health of the drainage ditch. We plan to fulfil our first objective through a field-scale water balance. To this end, the field has been instrumented with over 150 groundwater monitoring wells, six tile-drain and four drainage-ditch flow monitors, three soil lysimeters, and an automatic meteorological station. To date nearly 2000 groundwater, tile-drain, and ditch water samples have been collected. Weekly samples of biota are taken at a number of locations from the drainage-ditch bottom.

Preliminary results indicate a great deal of spatial variability exists in the quantity of nitrate in and below the tile drainage network. For the most part, nitrate concentration decreases rapidly with depth to virtually nil at 10 m below ground surface. Nitrate in groundwater that moves laterally is rapidly consumed in a natural vegetated buffer strip between the field and drainage ditch. However, two of six tile drain outlets deliver a significant quantity of nitrate to the ditch. In essence, water in tile drains bypasses the natural cleansing effects of the buffer strip. Water levels in tile drains increase relatively rapidly following rainfall events. Based on a natural element in rain, approximately 10% of rain water enters tiles directly, without the benefit of filtering through the soil matrix.

Biological studies of the ditch have concentrated on comparing the invertebrate fauna above and below the study field. While the total abundance of animals is the same in both areas, the composition of each community is substantially different. Species which are generally most sensitive to environmental degradation are less abundant downstream and more tolerant species are more abundant. These changes appear to reflect combined effects of loading of sediments and nutrients.

3.11 State of Resources: Improving the Land Resource Data Base - Waterloo Region

Contractor: Mr. D. Cressman, Ecologistics Limited, 490 Dutton Drive, Waterloo, ON N2L 6H7

Summary

The goal of this project was to produce a grouped soil polygon map and digital data set for the Regional Municipality of Waterloo. More specifically, the objective was to convert a very detailed 1:20,000 scale soil map (from *The Soils of Waterloo County*, Report Number 44 of the Ontario Soil Survey (Presant and Wicklund, 1971) on an uncontrolled photo mosaic base to a scale and level of detail that is more commonly used in land use and resource management planning (1:50,000 scale) and, in a Geographic Information System (GIS), to register the new soil map to the Ontario Base Mapping (OBM).

In a prior pilot project in Wilmot Township, soil polygons were grouped manually on the unregistered, published base maps and transferred to the OBM. In this project the intent was to utilize the GIS system as much as possible to group the polygons. Available from a previous project, undertaken by the Regional Municipality of Waterloo, was a complete digital data base for the 1:20,000 scale soil survey, and grouped soil polygon maps on a registered base. In order to assess the accuracy of the Region's grouped polygons, a plot of the polygons was compared with the manually-devised map of grouped soil polygons in Wilmot Township. Test results suggested the need for only minor changes to the digital soil grouping methodology.

In grouping soil polygons the available digital soil polygon data in the GIS were used to automate and accelerate the mapping process. Using the digital soils information from the Regional Municipality of Waterloo, soil polygons were first grouped according to the soil association parameters established in the Wilmot Township pilot project. Initially, adjacent soils of similar association were combined and polygon boundaries between these soils dissolved in the GIS. This reduced the number of soil polygons by approximately one half.

Next, hard copy maps were printed for each of the townships to show the distribution and sizes of grouped soil polygons. The maps were colour coded to show the relative sizes of soil polygons. Polygons smaller than the minimum size for map units were merged with the closest large polygon with similar soil materials. Soils were not grouped within the developed areas in subdivisions and other developed lands in the cities of Waterloo, Kitchener and Cambridge and in towns and hamlets across the Region.

Slope classes for each grouped soil polygon were determined using a combination of slope information in the original soil survey and OBM digital elevation data. The soil survey slope classes were modified to conform with current CanSIS standards. The OBM data were used to perform digital terrain mapping (DTM) and to derive slope classes in areas with slope gradients larger than 10 percent. The soil polygon slope fields were then combined to produce a generalized soil/slope polygon map for the Regional Municipality of Waterloo. The final step in the process was to assign soil capability ratings to the grouped soil polygons using modified Canada Land Inventory (CLI) ratings from *The Soils of Waterloo County*, Report Number 44 of the Ontario Soil Survey (Presant and Wicklund, 1971).